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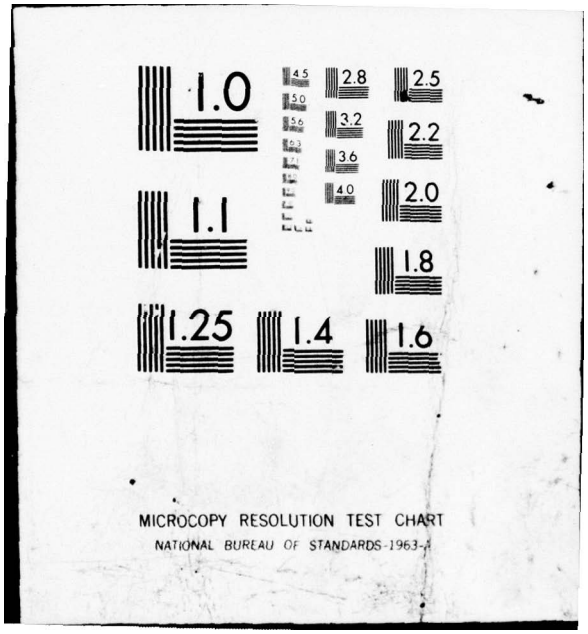
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AN EXPERIMENTAL DESIGN FOR MEASURING ATTITUDES TOWARD RISK OF PROGRAM MANAGEMENT PERSONNEL STUDY REPORT

PMC 73-1

Michael R. Thompson
LTC U.S. Army

AN EXPERIMENTAL DESIGN FOR MEASURING ATTITUDES TOWARD RISK OF PROGRAM MANAGEMENT PERSONNEL

An Executive Summary
of a
Study Report
by

Michael R. Thompson
LTC U.S. Army

May 1973

Defense Systems Management School
Program Management Course
Class 73-1
Fort Belvoir, Virginia 22060

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DEFENSE SYSTEMS MANAGEMENT SCHOOL

STUDY TITLE: AN EXPERIMENTAL DESIGN FOR MEASURING ATTITUDES TOWARD RISK OF PROGRAM MANAGEMENT PERSONNEL

STUDY PROBLEM/QUESTION: To develop an experiment which can be used to measure attitudes toward risk of program management personnel.

STUDY REPORT ABSTRACT: This report is based on the theses that: first, the attitudes toward risk by program management personnel are important; second, attitudes toward risk can be measured; and third, the research methodology for measurement of attitudes toward risk can be designed to provide useful results. Basic but limited research (under controlled conditions) of businessmen are examined. The tentative observations of the research are discussed. These observations have significant implications for the defense system aquisition process in the current environment of trade offs in cost, schedule and performance.

The report includes an experiment:

- Hypothesis.
- Instructions to Participants
- Scenario
- Methodology
- Interpretation of Results.

The experiment can be conducted by students attending the PMC and the results of the research submitted in Student Study Reports. The experiment is feasible within the resources available at the Defense Systems Management School. The body of knowledge derived from the research can then be used to refine communication and control procedures within the DoD system acquisition process.

Student, Rank Service	Class	Date
Michael R. Thompson LTC USA	73-1	May 1973

EXECUTIVE SUMMARY

This report is based on the theses that: first, the attitudes toward risk by program management personnel are important; second, attitudes toward risk can be measured; and third, the research methodology for measurement of attitudes toward risk can be designed to provide useful results.

Basic but limited research (under controlled conditions) of businessmen are examined. The tentative observations of the research are:

Businessmen do not attempt to optimize the expected dollar outcomes in risk situations.

Cardinal utility theory offers a reasonable basis for judging the internal consistency of a series of decisions.

Cardinal utility theory offers a relatively simple way of classifying types of decision makers i.e. risk adverse, risk neutral and risk seeking.

The action a junior executive recommends is a function of his "planning horizon".

Attitudes toward risk vary more widely in a given company than we are inclined to believe.

Decision makers tend to shun risk seeking decisions.

These observations have significant implications for the defense system acquisition process in the current environment of trade offs in cost, schedule and performance. There is no data or information

concerning the attitudes toward risk of program management personnel to either confirm or disprove the observations made in the research of businessmen. To this purpose an experiment is proposed to measure the attitudes toward risk of program management personnel attending the Executive Refresher Course and Program Management Course at the Defense Systems Management School (DSMS), Ft. Belvoir, Va.

The report contains such an experiment to include:

Hypothesis. Given the same environmental considerations (identical risk and consequences) in a decision involving risk, program management personnel--top executives and middle management--will have the same attitude toward risk.

Instructions to Participants.

Scenario. Adapted from environment of System X (DSMS Case Exercises).

Methodology.

Interpretation of Results.

The experiment can be conducted by students attending the PMC and the results of the research submitted in Student Study Reports. The experiment is feasible within the resources available at the Defense Systems Management School. The body of knowledge derived from the research can then be used to refine communication and control procedures within the DOD system acquisition process.

ACKNOWLEDGEMENTS

I would like to express my appreciation to David F. Dianich, Major USAF for his advice in the selection of this study subject as well as his patient advice and critique of this report.

Contents

AN EXPERIMENTAL DESIGN FOR MEASURING ATTITUDES TOWARD RISK OF PROGRAM MANAGEMENT PERSONNEL

STUDY REPORT

Presented to the Faculty

of the

Defense Systems Management School

in Partial Fulfillment of the

Program Management Course

Class 73-1

by

Michael R. Thompson
LTC U.S. Army

May 1973

AN EXPERIMENTAL DESIGN FOR MEASURING ATTITUDES TOWARD RISK OF PROGRAM MANAGEMENT PERSONNEL*

SECTION I

INTRODUCTION

This report is based on the theses that: first, the attitudes toward risk by program management personnel are important; second, attitudes toward risk can be measured; and third, the research methodology for measurement of attitudes toward risk can be designed to provide useful results. An experiment is proposed for measuring the risk attitudes of program managers and their staffs.

Risk and uncertainty are implicit conditions in the research and development of major defense systems. It is obvious there would be no decision problem if risk and/or uncertainty did not exist. A defense system would be produced and implemented once a solution had been identified. Decision making under the conditions of risk and uncertainty is defined in Executive Decisions and Operations Research by Miller and Starr. Risk is the condition when the decision maker knows or can estimate the probabilities of the various possible future outcomes of the research. Uncertainty is the condition when the decision maker does not know these probabilities and cannot

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*ABSTAINER

This study represents the views, conclusions and recommendations of the author and does not necessarily reflect the official opinion of the Defense Systems Management School nor the Department of Defense.

estimate them with any degree of confidence (1/pp. 89-94). The decision maker must be aware of the distinction because decisions under uncertainty depend on one's attitude toward risk such as risk adverse, risk neutral or risk seeking (2/p. 126).

Thus, it is vitally important that program managers and their staffs become aware of their attitudes toward risk as well as have a conceptual framework to make consistent decisions. Decision analysis is such a technique and has been used successfully for some time in the industrial and public sector (3). The oil drilling example is the classic case in academic and technical literature (4). Applications of decision analysis in weapons system acquisition are now being emphasized to identify "the risk of exceeding established thresholds of cost, schedule and technical performance" (5/p. 496).

It is also important the program manager realize that he must be willing to take risks in order to bring his system "home" at the predetermined cost within acceptable performance parameters and time frame. It is not sufficient to be adept in the mechanics of decision analysis. He must have an insight into his preference or non preference for risk. What purpose will a decision analysis serve if the program manager is unwilling to make a decision which requires him to take a chance? What will be the effect on a program if the program manager is unknowingly inconsistent concerning risk?

Decision analysis can be used as a management tool but, first there is a basic question which must be answered before we rush headlong into decision analysis. What are the attitudes toward risk of program managers and their staffs?

SECTION II

BACKGROUND AND CONCEPT FOR AN EXPERIMENTAL DESIGN FOR MEASURING ATTITUDES TOWARD RISK

Utility Theory

Cardinal utility theory proposed by Neumann and Morgenstern (6) has been used by researchers to study the risk attitudes of individuals. Ralph O. Swalm in Utility Theory-Insights into Risk Taking explains the use of the theory in this manner:

> . . . each individual has a measurable preference among various choices available in risk situations. This is called his utility. Utility is measured in arbitrary units which we call "utiles". By suitable questioning we can determine for each individual a relationship between utility and dollars which is called his utility function. This plot offers a picture of his attitude toward taking risks.
>
> In any decision involving risk, a man will choose that alternative which maximizes his utility. Once we know his utility function, the odds he assigns to events in a decision-making situation, and the consequences of each possible outcome, we should be able to predict his choice in that situation since he will attempt to maximize his utility (7/p. 124).

Swalm acknowledges that utility theory applications for measuring risk has not received universal acceptance among academicians. However, there has been increasing interest in the subject and practical interpretation of the results. Robert Schlaifer's Analysis of Decisions Under Uncertainty published in 1969 (2) and Howard Raiffa's Decision Analysis published in 1970 (8) devote considerable portions to cardinal utility theory applications of measuring decision makers' attitude toward risk.

TECHNIQUES

There is no general acceptance on the methodology to be used in assessing risk preference. Swalm's technique is to pose a situation in which the decision maker must determine his certainty equivalent or preference for the terminal event. The situations are then varied over a dollar range which the decision-maker is likely to experience in his job or his personal monetary resources (7/p. 130). The results can be plotted to determine the decision maker's general attitude toward risk in the form of a preference curve.

The determination of the decision maker's general attitude toward risk and interpretation of the preference curve is facilitated with the use of the concept of the risk premium. Schlaifer explains it this way:

> When a gamble gives <u>equal</u> chances at a number of terminal values, the amount by which a decision maker's certainty-equivalent terminal value falls short of the simple arithmetic average of the equally likely terminal values will be called his risk premium for the gamble:
>
> risk premium = average-certainty equivalent.
>
> Notice that the decision maker's risk premium for a 50-50 gamble will be
>
> positive if he is risk averse.
> zero if he is risk neutral.
> negative if he is risk seeking.
>
> as regards the gamble in question (2/p. 145).

Particular attention should be given to the environment of the decision maker in posing a situation or series of situations to determine his preference curve. The type of situation must be realistic. It must represent a range of values to which the decision maker can identify. Asking an individual to assess his certainty equivalents

for his personal monetary resources over a range of dollars two or three times his annual income would be valid only for a small range of the preference curve. The same caution would apply to assessments of certainty-equivalents in business or governmental environments. The situations described must conform to the decisions the individual is likely to make in the course of his normal decision making responsibility.

Research Results

A limited amount of research on the risk attitudes of businessmen has been conducted under controlled conditions. One experiment conducted by Swalm arrived at the following conclusions:

> . . .(1) Businessmen do not attempt to optimize the expected dollar outcome in risk situations involving what, to them are large amounts . . .
>
> (2) Cardinal utility theory offers a reasonable basis for judging the internal consistency of a series of decisions made by an executive dealing with risks . . .
>
> (3) The theory offers a relatively simple way of classifying many types of industrial decision makers. For example, a supervisor may learn that, in decisions involving significant risks, one man tends to be quite conservative, a second tends to be a gambler, and a third tends to be moderately conservative. If he is moderately conservative himself, he will be happier delegating decisions to the third than to either of the other two . . . (Measurement of risk preference) will reveal characteristics that are not readily apparent. It does this because it allows comparability (in real life, different executives usually face different problems and risks), shows a range of feeling about risk (in real life the boss is likely to get but one recommendation on a question), offers more objectivity (the subordinate's manner, his reputation, and other factors do not color the situation), and makes more precision possible . . .
>
> (4) The action a junior executive recommends in a risk situation is a function of his "planning horizon" (that is, it is related to the largest single amount he would recommend to

be spent) rather than to the financial condition and position of his company. If top management deems this undesirable (and to me this would almost certainly be the case), then the utility theory concept offers a promising way to begin corrective action.

(5) Attitudes toward risk decisions vary even more widely among various decision makers in a given company than we are inclined to think . . . utility theory offers a means of determining the degree to which this is true among decision makers in a company.

(6) . . . (Decision makers) rather than seeking risks, they shun them, consistently refusing to recommend risks that, from the overall company viewpoint, would almost surely be attractive (7/p. 135-36).

In so far as I have been able to determine no formal, controlled research measuring risk attitudes of program management personnel has been conducted. Recognizing that the research performed by Swalm was limited (only 100 businessmen were tested), his conclusions should be considered as observations in the practical applications of measuring risks. The research does place doubt on the rationality of an executive decision under uncertainty and risk.

SECTION III

THE NEED FOR MEASURING ATTITUDE TOWARD RISK OF PROGRAM MANAGEMENT PERSONNEL

Due to the lack of research in measuring risk attitudes of decision makers in general and program management personnel in particular, the question: "What are the attitudes of program managers and their staffs toward risk?" remains unanswered. The observations of Swalm based on his research have some serious implications for program management. If businessmen, who operate in an environment of high risk and are generally thought to be risk seekers are, in fact, conservative; then it may be possible that program managers share the same attitude. Does the same situation of the junior executive whose preference curve is a function of his planning horizon exist in the middle management staff in a program office? The possibility of a program staffer neglecting to advise a program manager of alternatives due to his notion of high risk may be just as great as that observed by Swalm.

Some consideration must be given to the nature and extent of risk in various defense system acquisition programs. A weapon system, such as the F-15 Air Superiority Fighter, has a far greater inter-related set of risks associated with its development and production than those of a new cargo truck. The successful completion of the F-15 comprises the full spectrum of risks from political, strategic and performance to cost and schedule. The cargo truck program will

have risks associated primarily with cost, schedule and performance and certainly with much lesser consequence. The environment is a critical factor in the risk attitude of individuals. Different risk attitudes among management personnel of the two programs should be expected depending on the consequences of alternatives. A basic research question is--do widely different attitudes toward risk exist between members of the same program management staff under identical conditions of risk and consequences? If such a case exists, the issue of whether difference in our attitudes is beneficial or detrimental should be examined. A program manager aware of the different risk attitudes could encourage or discourage them through communicating objectives and constraints and thereby influence risk attitudes downward in the management hierarchy.

To address the above research questions the following experimental design is recommended:

- The hypothesis.
- A scenario to create controlled conditions for risk and consequences.
- Methodology.
- Interpretation of results.

SECTION IV

ATTITUDE TOWARD RISK MEASUREMENT: AN EXPERIMENT

Introduction

The experiment shall be conducted on top program management executives attending the Executive Refresher Course and middle management personnel attending the Program Management Course (PMC) at the Defense Systems Management School, Fort Belvoir, Va. It is designed so several PMC students can conduct the experiment under controlled conditions and report the results as a Student Study Report. The experiment could be repeated over several class cycles or at different times during a class cycle to gather additional information.

The Hypothesis

Given the same environmental considerations (identical risk and consequences) in a decision involving risk, program management personnel--top executive and middle management--will have the same attitude toward risk.

Instructions to Participants

The scenario which will be given to you is based primarily on the environment which exists in System X. You are asked to perform an experiment in which you make a decision involving risk. A situation will be described in which you will be asked to choose between an alternative that will result in a certain gain of a known amount and another alternative that could result in either two outcomes.

Each outcome will be considered on the basis of the best information available to have a 50-50 chance of occurring. You will make the decision assuming the role of the program manager. It is essential that you make the decision in the particular context of the described situation and the general context of System X. Remember that you will be presented with two mutually exclusive alternatives. One will have a 50-50 chance between two possible outcomes; the second alternative will have certain outcome. The dollar amounts of two of the three possible final outcomes will be given; you will fix the amount of the third outcome in such a manner that you would be indifferent to the alternative between the 50-50 chance and the certain outcome.
Your decision will enable us to determine your attitude toward risk. This information will become part of a data base to evaluate the attitudes toward risk of defense systems program management personnel. Your answer will be held in confidence. Reports of results will not make reference to the names of participants.

Scenario

Brigadier General Ramrod, the Conqueror Missile Program Manager had just returned from an informal meeting with members of the Defense Systems Acquisition Review Council (DSARC). To say, the least, he was not at all happy with the "ultimatum" they passed on to him. Influential members of the Senate and House Appropriations Committee were very concerned about the escalating cost of weapons systems in DOD and the Conqueror Missile in particular. The "ultimatum" passed to General Ramrod was that unless he could show a reduction in the

discounted life cycle cost per unit by the time the next System Acquisition Report (SAR) goes to Congress, there was a strong possibility the program would be killed.

Charles Antwine, the Deputy Program Manager, met General Ramrod with more bad news. "We have more trouble with the launch vehicle. Last week, the Test and Evaluation Office of DDR&E notified us that the launch vehicle will not pass the Initial Operational Test unless the power train is modified."

"Agile evidently was expecting this as we received an urgent Engineering Change Proposal (ECP) the day after the call. We've had a crash program in the Program Office evaluating the ECP. Joe Brightman, (the program engineer) and his staff agree that the proposal will enable the power train to meet or exceed the test requirements. There is an interesting fall out of this proposal. One estimate indicates a 50-50 chance that the modification will increase the mean time between failures (MTBF) such that the discounted life cycle cost (DLCC) is reduced by $50,000 per unit. On the other extreme, it may reduce the DLCC by only $10,000. This same modification has been used frequently in the past with a very stable 50 percent success rate. The costs are estimated using the best DLCC simulation model we have."

"How much does Agile estimate it's going to cost us?", asked General Ramrod.

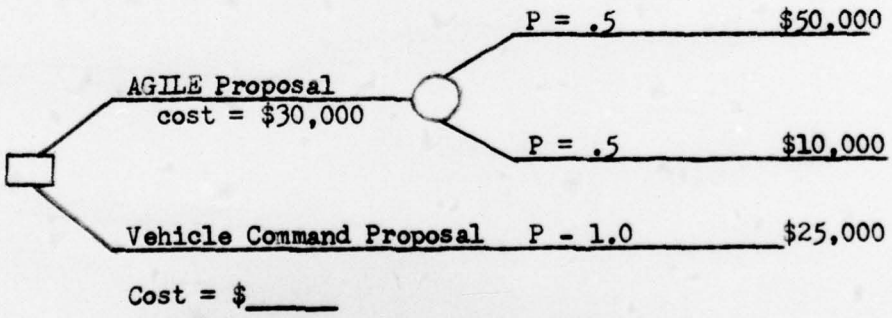
"$30,000 per unit", responded Brightman.

Antwine added, "We checked with Vehicle Command to see what they could do about the power train failures. They also have a modification which will enable the launch vehicle to meet the operational tests and are certain that it will reduce the DLCC by $25,000. They are basing this estimate on several successful applications recently. We obtained the DLCC figure using the same simulation model that we used for Agile's data. Joe Brightman agrees with their proposal and the estimated DLCC."

"And how much does the Vehicle Command figure their modification will cost us?" asked General Ramrod.

"The TWX from Vehicle Command was garbled in transmission so I don't have the cost. I've asked for a retransmission. General, I know you are leaving this morning for Europe to escort Congressmen for a month. If you tell me just how much you are willing to pay Vehicle Command in lieu of accepting the Agile ECP with its 50-50 chance, I can go ahead and make the decision if the Vehicle Command cost is less."

Antwine went to the blackboard and drew a decision tree.



"General, if you could tell me a cost for the Vehicle Command proposal at which you would be indifferent between Agile's ECP and the Vehicle Command's proposal, I will be able to make the decision. I will choose Agile's ECP if it is less than your estimate and the Vehicle Command's proposal if it is less than your estimate."

As General Ramrod what cost would you select?

The Results

The risk premium can be computed for each participant by subtracting the certainty equivalent from the average terminal value.

risk premium = average-certainty equivalent.

The risk premium for a 50-50 gamble will be:

positive if he is risk averse.
zero if he is risk neutral.
negative if he is risk seeking.

These results can then be grouped by the type of participants-ERC versus PMC students.

A graphical distribution of individual certainty-equivalents using a cumulative sample distribution plot will indicate the nature of the risk attitude as well as the differences in the attitude toward risk of the participating groups. A sample plot shown in Fig. A (next page) indicates the ERC group's attitude toward risk is more risk seeking than that of the PMC group.

The results can also be displayed and compared using a sample mass distribution plot (Fig. B). Here again, the ERC group's attitude toward risk is more risk seeking than that of the PMC group.

The primary hypothesis does not anticipate the variation between the two groups shown in Figs. A and B. The situation described for the decision maker is sufficiently detailed to allow him to fully appreciate the environment of the program and the required decision.

Should a significant variation in the attitudes toward risk occur between the two groups, it will open new areas for investigation and research. For example, if the research results indicated that the

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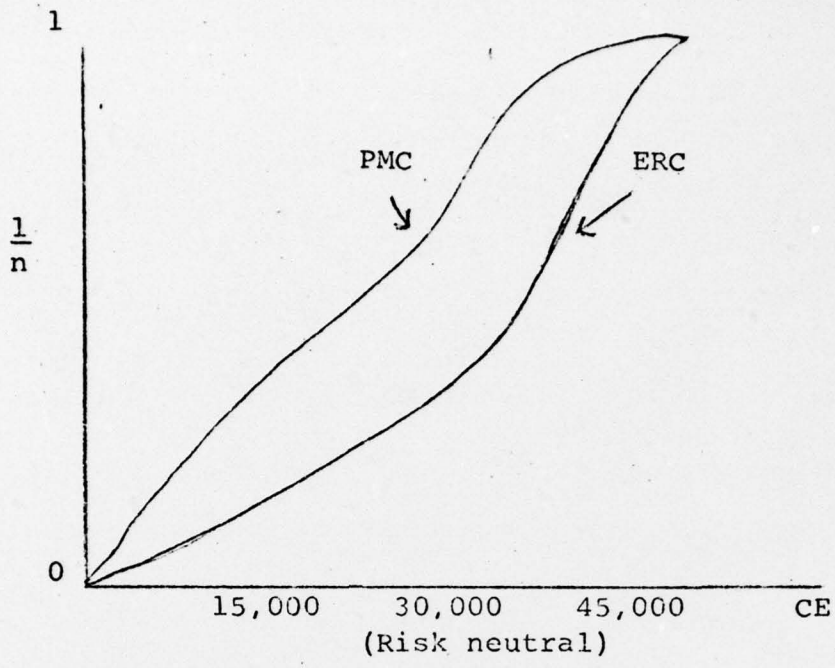
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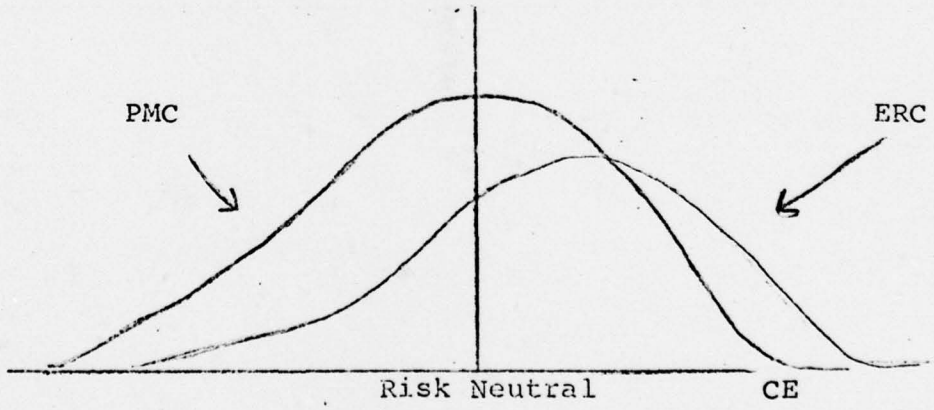
1/n
0
PMC
ERC
15,000
30,000
45,000
CE
(Risk neutral)


PMC
ERC
Risk Neutral
CE

top executives in the ERC group were risk seeking and the middle management personnel were risk adverse, the following factors might be investigated:

Program management experience versus risk attitude.

Career status versus risk attitude.

Personal net worth versus risk attitude.

Planning horizon versus risk attitude.

Educational background versus risk attitude.

Professional experience (engineer, comptroller) versus risk attitude.

The research could be expanded also to examine the attitudes toward risk of program management personnel assigned to a particular program office to further test the validity of the hypothesis.

SECTION V

CONCLUSION

The proposed experiment is feasible within the resources available to a PMC student. Conducted over several class cycles, it will be a significant addition to the basic insights on the attitudes of program managers and their staffs toward risk.

Risk analysis and risk attitudes have escalated in importance in recent years due to the changing environment within the DOD and Congress. Once the basic risk attitudes of individuals charged with the responsibility and authority for developing and procuring weapons systems, the proper and possibly increased emphasis on understanding risk can be pursued by the Defense Systems Management School.

The number of possibilities for research experiments subsequent to the one I proposed are limited only by the imagination of the researcher. Experiments designed to determine the entire risk preference curve of individuals and groups; and, experiments designed to measure the effect on attitudes toward risk by varying the environmental and technical information are only two of many possibilities which would give further insight into risk attitudes of program management personnel. Moreover, System X gives the researcher a controlled environment essential to valid research and could be used advantageously to address the issue of risk attitudes. This body of knowledge could then be used to refine communication and control procedures within the DOD system acquisition process.

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